

# NGC 6994: an open cluster which is not an open cluster<sup>\*</sup>

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**Abstract.** We report on CCD photometry in the Johnson  $B$ ,  $V$  and  $I$  passbands for 146 stars in a  $9' \times 9'$  region around the southern aggregate NGC 6994 (C 2056-128), which appears in the Lyng  (1987) catalogue of open star clusters. We argue that this object is not really an open cluster, but simply a random enhancement of four bright stars above the background level. This stars sample includes HD 358033 and GSC 05778-0082, together with M 73, which is referred to as a binary or multiple star, but actually represents the whole asterism. Since NGC 6994 is not the first case (see for instance Carraro & Patat 1995), this raises the possibility that other open clusters may have been misclassified. We also suggest that NGC 6994 is unlikely to be an open cluster remnant (OCR).

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**Key words:** Open clusters and association : general – Open Cluster and associations : individual : NGC 6994 – Hertzsprung-Russel (HR) Diagram

## 1. Introduction

The disk of the Milky Way harbors about 1200 open clusters. The youngest ones trace the spiral pattern in the disk, whereas the oldest ones are ideal templates to study the chemical and dynamical evolution of the disk, together with the Star Formation History (Friel 1995).

Open star clusters are usually studied by analyzing the Color Magnitude Diagram (CMD, Chiosi et al 1992).

Despite the importance of these objects for our understanding of the disk properties, CMDs are at present available only for a small fraction of the clusters population, say 40%. However the situation is rapidly changing thanks to dedicated surveys like for instance the PLCON (Palo-mar Las Campanas Observatory NOAO) Open Clusters Survey (Phelps 1999).

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<sup>\*</sup> Based on observations carried out at ESO, La Silla.

One of the crucial problem with open clusters is that they are highly contaminated by field stars in the disk, so that it is rather difficult to obtain precise estimates of their fundamental parameters.

This way many clusters remain completely unstudied but for the identification, which in most cases is done on a by eye basis, by inspecting at several different sky charts.

In some cases the identification is made by recognizing a peak of star concentration in the field. This is naturally a good criterion, which however deserves further studies to confirm the real nature of the star enhancement.

This is not only a semantic question. A star cluster is doubtless a star enhancement in the field.

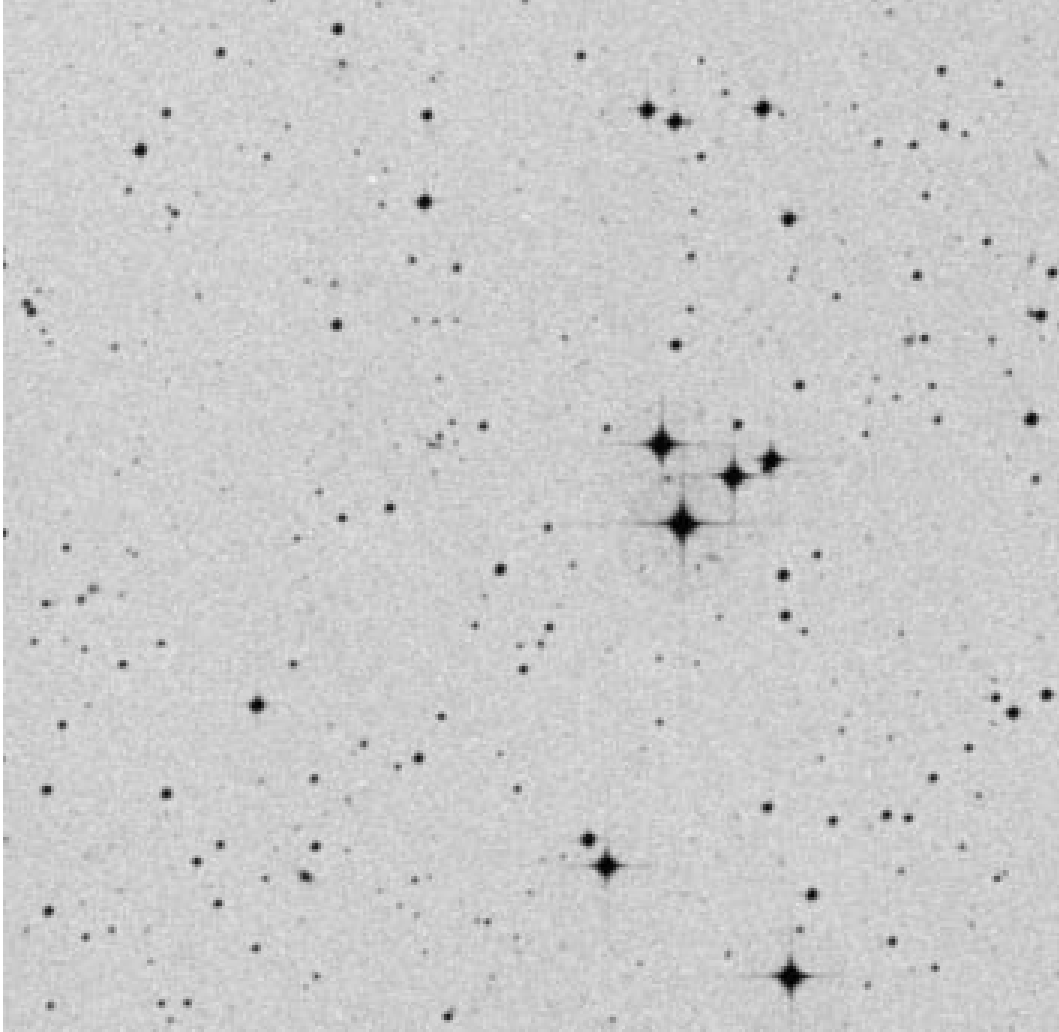
Nonetheless the real nature can be unraveled with higher degree of confidence by looking at the CMD, and recognizing typical features, like a Main Sequence of H-burning stars, a Red Giant Branch, and/or a clump of He-burning stars (Chiosi et al 1992).

For instance Carraro & Patat (1995) analyzed photometry for the presumed old cluster Ruprecht 46, and concluded that it is not a cluster, but only a random enhancement of bright stars.

Recently, de la Fuente Marcos (1998) has performed numerical simulations of open clusters evolution, suggesting that many star concentrations in the sky may be OCRs. The basic criterion is the evidence of a star concentration higher than the field stars. So in principle an enhancement of stars could be just the final stage of the evolution of an open cluster.

In this paper we present  $B$ ,  $V$  and  $I$  photometry for NGC 6994, an object which appears in the Lyng  (1987) open clusters catalogue and that it is classified as open cluster also by SIMBAD.

The aim is to provide some photometric data for this cluster, complementing the very poor informations we have, which basically consists of the cluster identification and diameter, which according to Lyng  (1987) is about 1.0 arcmin. Its coordinates for the 2000.0 equinox are:  $\alpha = 20^h 59^m 00^s$ ,  $\delta = -12^\circ 38'$ ,  $l = 35^\circ.73$ ,  $b = -33^\circ.95$ .



**Fig. 1.** A DSS  $10 \times 10$  arcmin<sup>2</sup> image in the region of the open cluster NGC 6994. North is on the top, east on the left. The two brighter stars in the asterism are GSC 05778–0082 and HD 358033, respectively.

NGC 6994 is expected to lie close to HD 358033, GSC 05778–0082, and M 73. This latter might be a binary or multiple system according to SIMBAD, but more probably represents all the asterism.

From the acquired data, it turns out that NGC 6994 is not a cluster, but just a random enhancement of the four mentioned bright stars.

Section 2 is dedicated to a brief description of the data acquisition and reduction; Section 3 deals with the cluster structure and CMD. Finally Section 4 summarizes the results.

## 2. Data Acquisition and Reduction

Observations were conducted at La Silla on 1999 October 8, using the Tektronix  $2024 \times 2024$  pixel CCD # 36 mounted in the red EMMI arm of the 3.6-m ESO NTT telescope. The reader is referred to Maris et al (2000) for

any detail about data reduction and acquisition.

Magnitudes and colors of all the observed stars are available upon request, together with the frame coordinates ( $X$  and  $Y$ ) and the instrumental ALLSTAR rms errors  $\sigma$ .

## 3. The cluster

### 3.1. Preliminary considerations

NGC 6994 is a poorly known object. It is classified as a Trumpler (1930) *IV 1 p* cluster, say a poorly populated (4 stars?) and compact system. This classification however is doubtful. Many observers detected this stars concentration, which was baptized also as M 73, Cr 426, C 2056-128, and OCL 89 (Ruprecht 1966). Its angular diameter is estimated to range between 1 to 2.8 arcmin, which means that it should be a rather compact cluster (Collinder (1931) suggested it is a globular).

**Table 1.** Basic parameters of the two brighter stars in NGC 6994 region. Magnitudes, proper motions and trigonometric parallax are from the Tycho catalogue.

Name	$\alpha(2000.0)$ hh:mm:ss	$\delta(2000.0)$ ( $^{\circ}$ )( $'$ )( $''$ )	$B$	$V$	$\mu_{\alpha}$ "/yr	$\mu_{\delta}$ "/yr	Spectral type	$\pi$ mas	dist pc
HD 358033	20:58:57.9	-12:37:45.9	11.915	11.170	0.0190	-0.006	F5	7.40	135
GSC 05778-00802	20:58:56.7	-12:38:30.1	11.688	10.427	0.0075	-0.011		23.80	42

It seems that all these suggestions converge to the conclusion that we have to consider NGC 6994 as a group of four bright stars shown in Fig. 1.

### 3.2. The structure

NGC 6994 is a cluster located at relatively high galactic latitude ( $b = -33.95$ ). It appears as a concentration of four bright stars in the DSS image presented in Fig 1, although the barycenter of these stars is offset with respect to the commonly reported cluster center, which corresponds to the center of the image. These four stars are rather close, justifying the small diameter reported by Lyngå (1987), who presumably referred to these stars when describing NGC 6994 properties. In details, the two brighter stars are HD 358033 and GSC 05778-0082, and their parameters are listed in Table 1, where magnitudes ( $B$  and  $V$ ), distance and proper motions are from Tycho catalogue (Høg et al 1998). Typical errors affecting these magnitudes are 0.3-0.4 mag. These two stars are well inside the solar neighborhood, and lie 135 and 42 pc from the Sun, respectively. M 73 according to Simbad is a double or multiple star, but most probably represents the whole asterism, and it could be considered as a duplicate name for NGC 6994. Moreover we noticed that the faintest star in the asterism might be a visual binary, or simply the two stars are projected in the same sky direction. It is however rather unlikely to imagine that this binary system actually represents M 73. Apart from these four stars, no many other stars are visible close to the cluster center which could justify the classification of this object as an open cluster. Indeed the surrounding field (see Fig. 1) appears very smoothly populated. Looking at the cluster structure it is reasonable to suggest that these four stars are responsible for the by eye identification of this aggregate as an open cluster.

### 3.3. The CMD

The measured stars in the plane  $V$  versus  $(B - V)$  and  $V$  versus  $(V - I)$  are shown in Fig. 2 (left and right panel, respectively), and represent a region somewhat smaller ( $9 \times 9$  arcmin<sup>2</sup>) than that shown in Fig. 1. They define a broad vertical sequence which gets wider at increasing magnitude. The distribution of stars does not exhibit any distinguishing feature, but resembles a typical field stars CMD. The straightforward conclusion is that NGC 6994

is not an open cluster, but the stars in this region define a rather smooth field population, with some voids and less rich in stars than the typical galactic disk fields. We must stress that we are looking at a relatively high galactic latitude, where the thickness of the disk is rather small.

### 3.4. Is NGC 6994 an open cluster remnant?

de la Fuente Marcos (1998) studied the dynamical evolution of open star clusters, suggesting that the final stage of their evolution consists of a handful of stars which emerges from the general galactic field. The life-time, number of remaining stars and dimension of the OCR depends on the initial cluster size and on the distance to the galactic center. As for NGC 6994, we find that there are 11 stars which significantly emerge from the field (see Fig. 2). This would mean that NGC 6994 was a rich open cluster with an initial population of about 700 stars, and an age of almost a billion yrs, or a younger (half a billion yrs) initially less rich (250 stars) open cluster if the binary population was significant (30%). Since NGC 6994 does not have bright stars (the two brightest ones are probably dwarfs), the most plausible conclusion would be that it was initially a rich populated cluster, with an age of 1 Gyr or more. There are however not enough arguments leading to this scenario. In fact the lack of any feature in the CMD is a strong argument against the classification of this object as an open cluster. Indeed moving groups and OCR actually maintain in time some structures resembling a cluster CMD (see de la Fuente Marcos, 1998, Fig. 3).

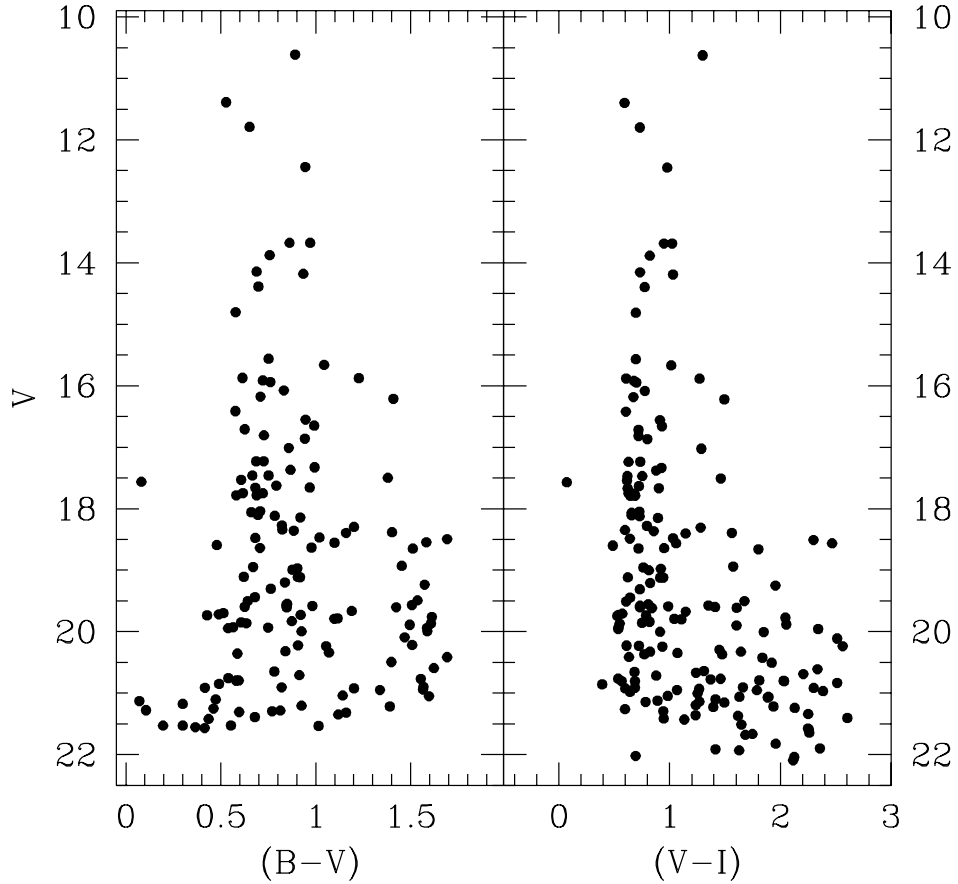
The most reasonable conclusion is that we are looking at the general galactic field, with stars at any distance from the Sun.

## 4. Conclusions

We reported on photometry in  $B$ ,  $V$  and  $I$  passbands for NGC 6994, an object previously classified as open cluster. The analysis of the observed cluster field, and the distribution of the stars in the CMD seems to favor the suggestion that this object is not really an open cluster, but simply an enhancement of four bright stars in the general galactic field.

The conclusion of this work can be summarized as follows:

- NGC 6994 is an asterism of four stars and not an open cluster;



**Fig. 2.** The CMD of the measured stars in the region of NGC 6994 in the  $V$  vs  $(V-I)$  (right panel) and  $V$  vs  $(B-V)$  (left panel) planes.

- NGC 6994 is unlikely to be an OCR;
- M 73 should not be considered a binary system; instead it can be used as a duplicate name for NGC 6994;

Carraro & Patat (1995) found another object classified as open cluster - Ruprecht 46 - which was proved to be just a random fluctuation in the field of the galactic disk. We wonder whether the possibility exists that some other unstudied or poorly studied open clusters might not be real open clusters, but OCRs or just random star concentration fluctuations in the galactic disk.

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